Claims:

1. Apparatus for growing single crystal silicon comprising:

a crucible adapted to contain a melt;

a lift mechanism located over the crucible;

a support body suspended from the lift mechanism; and

a pivoted member comprising at least one rod holder suitable for holding a silicon rod and a single crystal seed held in a fixed position relative to the rod holder, the pivoted member being pivotally mounted on the support body for movement relative to the support body about a generally horizontal pivot axis and the pivoted member having a center of gravity located such that, when at least one silicon rod is connected to the pivoted member, the pivoted member is positioned with the rod holder extending downwardly and, when no silicon rods are connected to the pivoted member, the pivoted member is positioned with the seed extending downwardly.

2. The apparatus of claim 1 further comprising at least one rod of silicon suspended from the pivoted member such that the rod hangs over the crucible, the rod having a free end nearest the crucible and an attached end at the top of the suspended rod, the rod defining a transversely extending groove that opens upwardly at the attached end, with the pivoted member engaging the rod only at a level above the bottom of the groove.

3. The apparatus of claim 2 comprising a plurality of rod holders and a plurality of silicon rods, with each of the rods being supported by one of the rod holders.

4. The apparatus of claim 2 wherein:

the groove is a keyhole that has a neck portion and a body portion located below the neck portion, with the neck portion being narrower horizontally than the body portion; and

the rod holder is received in the keyhole and is shaped to have a neck portion and a body portion located below the neck portion with the neck portion of the rod holder being narrower horizontally than the neck portion of the keyhole, the body portion of the rod holder being narrower horizontally than the body portion of the keyhole, and the body portion of the rod holder being wider horizontally than the neck portion of the keyhole so that the rod rests on the head portion of the rod holder.

5. The apparatus of claim 2 wherein:

the rod has a generally cylindrical side surface that defines one or more recesses; and

the pivoted member further comprises a ring ditch holder that has two or more prongs that extend generally inwardly toward the axis of the rod and that are received in the one or more recesses.

6. The apparatus of claim 5 wherein:

the one or more recesses is a ring ditch that encircles and extends inwardly from the generally cylindrical side surface at a location below the top of the rod to provide a radially extending flange that has a lower surface extending substantially perpendicular to the rod axis; and

the lower surface rests on at least two of the prongs.

7. A rod replenishment mechanism comprising:

a support body;

a pivoted member comprising at least one rod holder suitable for holding a rod and a single crystal seed in a fixed position relative to the rod holder, the pivoted

member being pivotally mounted on the support body for movement relative to the support body about a pivot axis; and

an attachment for connecting the support body to a seed cable or shaft of a CZ furnace so that when the support body is connected to the seed cable or shaft of the CZ furnace, the pivot axis will extend generally horizontally and the rod replenishment mechanism can be raised or lowered by appropriate operation of the seed cable or shaft.

8. The mechanism of claim 7 wherein:

the free end of the seed and each rod holder lie in a plane that includes the pivot axis; and

the seed extends in a direction away from the pivot axis and the rod holder extends in the opposite direction away from the pivot axis.

9. Apparatus for growing single crystal silicon comprising:

a crucible adapted to contain a melt;

a lift mechanism located over the crucible;

a support body suspended from the lift mechanism; and

a pivoted member comprising at least one rod holder suitable for holding a silicon rod and a single crystal seed in a fixed position relative to the rod holder, the pivoted member being pivotally mounted on the support body for movement relative to the support body about a generally horizontal pivot axis and the pivoted member having a center of gravity located such that, when at least one silicon rod is connected to the pivoted member, the pivoted member is positioned with the rod holder extending downwardly and, when no silicon rods are connected to the pivoted member, the pivoted member is positioned with the seed extending downwardly.

10. The apparatus of claim 9 wherein:

the apparatus further comprises a silicon rod that has a generally cylindrical side surface that defines one or more recesses; and

the pivoted member further comprises ring ditch holder that has two or more prongs that extend generally inwardly toward the axis of the rod and that are received in the one or more recesses.

11. A rod of silicon that:

has a rod surface including a generally cylindrical side surface and a top surface at one end of the side surface;

has a rod axis that is surrounded by and extends generally parallel to the cylindrical side suface;

defines at least one recess that extends inwardly from the rod surface toward the rod axis; and

defines a transversely extending groove that extends across at least a portion of the top surface and that has a bottom at a location farther from the top surface than that portion of the at least one recess that is nearest the top surface.

12. The rod of claim 11 wherein the at least one recess is a ring ditch that encircles and extends inwardly from the generally cylindrical side surface at a location below the top of the rod to provide a radially extending flange that has a lower surface extending substantially perpendicular to the rod axis.

13. A method for growing single crystal silicon, the method comprising:

providing a furnace having a crucible adapted to contain a melt and having a lift mechanism that can be operated to lower an object inside the furnace;

providing a rod replenishment mechanism suspended from the lift mechanism, the rod replenishment mechanism comprising a support body and a pivoted member that comprises at least one rod holder suitable for holding a silicon rod and a single crystal

seed in a fixed position relative to the rod holder, the pivoted member being pivotally mounted on the support body for movement relative to the support body about a generally horizontal pivot axis;

suspending at least one rod of silicon from the rod replenishment mechanism such that the rod hangs over the crucible;

operating the lift mechanism to lower the at least one rod into the crucible; and

heating, while the at least one rod is being lowered, to melt at least the lowest portion of the rod.

14. The method of claim 13 wherein the rod:

has a surface including a generally cylindrical side surface and a top surface nearest the top of the furnace; and

defines a transversely extending groove that opens upwardly at the top surface and that has a bottom that extends, at a level below the rod replenishment mechanism, between two locations on the surface of the rod.

15. The method of claim 14 further comprising continuing to lower the at least one rod until all that remains unmelted are separate rod pieces on opposite sides of the groove, which pieces fall away from the rod holder and into a melt in the crucible.

16. The method of claim 14 wherein the groove is a keyhole that has a neck portion and a body portion located below the neck portion, with the neck portion being narrower horizontally than the body portion.

17. The method of claim 16 wherein the rod holder is received in the keyhole and is shaped to have a neck portion and a body portion located below the neck portion with the neck portion of the rod holder being narrower horizontally than the neck portion of the keyhole, the body portion of the rod holder being narrower horizontally

than the body portion of the keyhole, and the body portion of the rod holder being wider horizontally than the neck portion of the keyhole so that the rod rests on the head portion of the rod holder.

18. The method of claim 13 wherein:

the rod replenishment mechanism comprises a single crystal seed; and

the method further comprises operating the lift mechanism to dip the seed into the melt and then to raise the seed to pull a single crystal ingot from the melt.

19. The method of claim 18 wherein the single crystal seed is the lowermost portion of the rod replenishment mechanism after the at least one rod has been lowered to the elevation at which no portion of the rod remains attached to the holder.

20. A method for melting a silicon rod, the method comprising:

suspending a silicon rod from a suspension mechanism such that the rod hangs over a crucible, the rod having a surface including a generally cylindrical side surface and a top surface nearest the top of the furnace, the rod defining at least one recess in the cylindrical side surface, which at least one recess receives the suspension mechanism, and the rod defining a transversely extending groove that opens upwardly at the top surface and that has a bottom that is lower than the suspension mechanism that supports the rod;

lowering the rod into the crucible;

heating, while the rod is being lowered, to melt at least the lowest portion of the rod; and

continuing to lower the rod until all that remains unmelted are separate rod pieces on opposite sides of the groove, which fall away from the suspension mechanism and into the crucible.

21. A method for preparing a silicon rod, that has a surface including a generally cylindrical side surface and a top surface, for suspension in a furnace, the method comprising:

forming a transversely extending groove that extends across at least a portion of the top surface; and

forming a ring ditch that extends inwardly from the generally cylindrical side surface and encircles at least a portion of the generally cylindrical side surface to provide a radially extending flange that has a lower surface extending substantially perpendicular to the rod axis with the lower surface of the flange being closer to the top surface than is the bottom of the groove.

22. Apparatus for growing single crystal silicon comprising:

a crucible adapted to contain a melt;

a lift mechanism located over the crucible;

a rod holder supported by the lift mechanism; and

a silicon rod suspended from the rod holder such that the rod hangs over the crucible, the rod having a free end nearest the crucible and an attached end at the top of the suspended rod, the rod defining a transversely extending groove that opens upwardly at the attached end, with the rod holder engaging the rod only at a level above the bottom of the groove.

23. The system of claim 22 wherein the groove is a keyhole that has a neck portion and a body portion located below the neck portion, with the neck portion being narrower horizontally than the body portion.

24. The system of claim 23 wherein the rod holder is received in the keyhole and is shaped to have a neck portion and a body portion located below the neck portion, with the neck portion of the rod holder being narrower horizontally than the neck

portion of the keyhole, the body portion of the rod holder being narrower horizontally than the body portion of the keyhole, and the body portion of the rod holder being wider horizontally than the neck portion of the keyhole so that the rod rests on the head portion of the rod holder.

25. The system of claim 22 further comprising a single crystal seed supported by the lift mechanism.

26. A system for melting a silicon rod, the system comprising:

a crucible adapted to contain a melt;

a lift mechanism located over the crucible;

a rod holder supported by the lift mechanism; and

a silicon rod suspended from the rod holder such that the rod hangs over the crucible, the rod having a free end nearest the crucible and an attached end at the top of the suspended rod, the rod defining a transversely extending groove that opens upwardly at the attached end, with the rod holder engaging the rod only at a level above the bottom of the groove.

27. The system of claim 26 wherein the groove is a keyhole that has a neck portion and a body portion located below the neck portion, with the neck portion being narrower horizontally than the body portion.

28. The system of claim 27 wherein the rod holder is received in the keyhole and is shaped to have a neck portion and a body portion located below the neck portion with the neck portion of the rod holder being narrower horizontally than the neck portion of the keyhole, the body portion of the rod holder being narrower horizontally than the body portion of the keyhole, and the body portion of the rod holder being wider

horizontally than the neck portion of the keyhole so that the rod rests on the head portion of the rod holder.

29. A rod of silicon that:

has a generally cylindrical side surface;

has a top surface at one end of the side surface; and

defines a transversely extending groove that extends across at least a portion of the top surface, at least a portion of the groove being a keyhole that has a neck portion that extends axially inwardly from the top surface and a body portion located axially inwardly from the neck portion, with the neck portion being narrower, as measured transversely, than the body portion.

30. A method for growing single crystal silicon, the method comprising:

providing a furnace having a crucible adapted to contain a melt, having a lift mechanism that can be operated to lower an object inside the furnace, and having a rod holder supported by the lift mechanism;

suspending a rod of silicon from the rod holder such that the rod hangs over the crucible, the rod having a surface including a generally cylindrical side surface and a top surface nearest the top of the furnace, the rod defining a transversely extending groove that opens upwardly at the top surface and that has a bottom that extends, at a level below the rod holder, between two locations on the surface of the rod;

operating the lift mechanism to lower the rod into the crucible;

heating, while the rod is being lowered, to melt at least the lowest portion of the rod;

continuing to lower the rod until all that remains unmelted are separate rod pieces on opposite sides of the groove, which fall away from the rod holder and into a melt in the crucible; and

dipping a single crystal silicon seed into the melt; and

then raising the seed to pull a single crystal ingot from the melt.

31. The method of claim 30 wherein the groove is a keyhole that has a neck portion and a body portion located below the neck portion, with the neck portion being narrower horizontally than the body portion.

32. The method of claim 31 wherein the rod holder is received in the keyhole and is shaped to have a neck portion and a body portion located below the neck portion with the neck portion of the rod holder being narrower horizontally than the neck portion of the keyhole, the body portion of the rod holder being narrower horizontally than the body portion of the keyhole, and the body portion of the rod holder being wider horizontally than the neck portion of the keyhole so that the rod rests on the head portion of the rod holder.

33. A method for melting a silicon rod, the method comprising:

suspending a silicon rod from a lift mechanism such that the rod hangs over a crucible, the rod having a surface including a generally cylindrical side surface and a top surface nearest the top of the furnace, the rod defining a transversely extending groove that opens upwardly at the top surface and that has a bottom that is lower than the suspension mechanism that supports the rod;

lowering the rod into the crucible;

heating, while the rod is being lowered, to melt at least the lowest portion of the rod; and

continuing to lower the rod until all that remains unmelted are separate rod pieces on opposite sides of the groove, which fall away from the suspension mechanism and into the crucible.

34. The method of claim 33 wherein the groove is a keyhole that has a neck portion and a body portion located below the neck portion, with the neck portion being narrower horizontally than the body portion.

35. The method of claim 34 wherein a rod holder is supported by the lift mechanism, is received in the keyhole, and is shaped to have a neck portion and a body portion located below the neck portion with the neck portion of the rod holder being narrower horizontally than the neck portion of the keyhole, the body portion of the rod holder being narrower horizontally than the body portion of the keyhole, and the body portion of the rod holder being wider horizontally than the neck portion of the keyhole so that the rod rests on the head portion of the rod holder.

36. A method for preparing a silicon rod, that has a surface including a generally cylindrical side surface and a top surface, for suspension in a furnace, the method comprising forming a transversely extending groove that extends across at least a portion of the top surface, at least a portion of the groove being a keyhole that has a neck portion that extends axially from the top surface and a body portion located axially inwardly from the neck portion, with the neck portion being narrower, as measured transversely, than the body portion.